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SUGGESTED SAFETY RULES FOR INSTALLING AND USING ELECTRICAL EQUIPMENT IN COAL MINES

BY

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SUGGESTED SAFETY RULES FOR INSTALLING AND USING ELECTRICAL EQUIPMENT IN COAL MINES[1]

By L. C. Ilsley[2] and Charles M. Means[3]

DEFINITIONS

The descriptive rather than the strictly technical meaning of many of the terms and expressions used in the electrical rules is given in order to assist in their interpretation.

ALIVE. At a potential measurable with a voltmeter and different from that of the earth or another conductor. (Static charges should be determined with an electrostatic voltmeter. This condition may apply to current-carrying parts, to noncurrent-carrying parts and adjacent material where a failure of insulation has taken place, and to objects having stored or static electricity.)

ALTERNATING CURRENT. A current that changes in direction--positive or negative--a certain number of times per second, depending upon the number of poles and speed of the generator.

AMMETER. An instrument for measuring current, indicating in amperes.

AMPERE. A term applied to denote the rate of current flow. (Analogous to "gallons per minute" in a hydraulic system.)

APPROVED. Accepted as suitable by a competent committee, board, or organization designated by those adopting the rules.

ARMOR. A steel or equivalent metallic covering for one or more electric conductors.

AUTHORIZED PERSON. Anyone commissioned by the official in charge of the mine or his deputies to carry out certain duties incident to the generation, transformation, and distribution or use of electric energy in the mine, such person being one who is competent within the purpose of the rule in which the term is used.

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[1] - The Bureau of Mines will welcome reprinting of this paper, provided the following footnote acknowledgment is used: "Reprinted from U. S. Bureau of Mines Information Circular 6269."

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CABLE. (1) A stranded conductor (single conductor cable); (2) a combination of conductors insulated from one another (multiple conductor cable).

CHARGED. Possessing a potential different from that of the earth and measurable with a voltmeter. (More commonly applied to objects having stored static electricity.)

CIRCUIT BREAKER. A current-rupturing device which can be adjusted to open an electric circuit at a predetermined current value.

CONDUCTOR. A wire or combination of wires not insulated from one another, suitable for carrying a single electric current.

CONDUIT. One or more tubes or runways especially constructed for the purpose of inclosing electrical conductors.

CONTACTOR. A device for repeatedly establishing and interrupting an electric circuit under normal conditions.

CURRENT. Electricity in motion.

DELTA CONNECTION. Applicable to windings in 3-phase systems - diagrammatically shown as equilateral triangles.

DIRECT CURRENT. A current in one direction.

ELECTRICAL SYSTEM. All apparatus and circuits receiving electrical energy or that may receive electrical energy from a common source. (Where the generator - source of power - is under control of the mine it will be considered a part of the electrical system. If power is obtained from a central station, the electrical system shall refer only to that part of the system under the control of the mine).

ELECTRIC CIRCUIT. All conductors including ground returns furnishing energy to or receiving energy from electrical apparatus.

ELECTRIC LOCOMOTIVE. A machine designed and constructed to haul cars in mines and receiving its driving energy from electric motors.

EXPLOSION-PROOF CASING OR INCLOSURE. A casing or an inclosure which can withstand, without injury, any explosion of methane-air mixtures that may occur within it and will not transmit the flame to methane-air mixtures surrounding it.

FUSE. A current-rupturing device designed to melt or dissipate at a predetermined current value within prescribed time limits and intended to protect circuits or apparatus against abnormal overloads.

GENERATING STATION. A power station in which generators are installed.

GENERATOR. A machine which transforms mechanical power into electrical power.

GROUNDED. Effectively connected to the earth so that there shall be a path of low resistance between the object grounded and the earth.

GROUND RETURN. A metallic conductor, some portion of which is in close contact with the earth, making the entire conductor at practically earth potential. (For example, a mining-machine circuit which in part uses a bonded rail return).

GROUNDED SYSTEM. A system having one terminal or point permanently grounded. (In direct-current installation this is usually the negative terminal of the generator. In a 3-phase star-connected system the center or neutral point of the star is grounded).

GROUNDING. See Grounded.

GUARDED. Effectively covered, inclosed, or otherwise shielded by means of suitable covers, casings, screens, or barriers to prevent accidental contact with live parts of apparatus or circuits.

HORSE POWER. The practical unit of mechanical power, equivalent to 746 watts of electrical power.

INSULATED. Guarded or covered with nonconducting material.

KILOWATT. A practical unit of electrical power equal to 1000 watts and equivalent to approximately 1-1/3 horsepower.

LIGHTNING ARRESTER. A device for dissipating excessive voltage charges caused by lightning or other abnormal conditions.

LIVE. See definition for ALIVE.

METHANE-DETECTING DEVICE. An apparatus for detecting the approximate percentage of methane in mine atmospheres (flame safety lamps, Burrell methane indicator).

MOTOR. A machine which transforms electrical power into mechanical power.

NATIONAL ELECTRICAL CODE. A code of regulations prepared by the National Board of Fire Underwriters to govern the proper installation and maintenance of electrical equipment, the underlying purpose being to prevent electrical fire hazard.

NATIONAL ELECTRICAL SAFETY CODE. A code of regulations prepared by the Bureau of Standards to govern the proper installation and maintenance of electrical equipment, the underlying purpose being to prevent electrical accidents.

OPEN DELTA. An arrangement using but two windings of a 3-phase delta layout.

OHM. The practical unit of electrical resistance, (analogous to a valve or restriction in a hydraulic system).

PHASE. An electrical term used to denote time characteristics of the voltage or current waves in an alternating current circuit, or to express time relations between current and voltage phenomena.

PERMISSIBLE EQUIPMENT OR APPARATUS. Equipment or apparatus that is listed in the United States Bureau of Mines for use in coal mines where methane or coal dust, or both, may inadvertently be present in dangerous proportions.

PORTABLE ELECTRIC MINERS' LAMPS. Battery lamps used by miners, and similar lamps used on animals and for signal purposes.

PORTABLE MOTORS. Motors that are intended for service here and there as occasion requires and that are so constructed or mounted as to facilitate moving them from place to place.

POTENTIAL. Electrical level or pressure expressed in volts (analogous to head in a hydraulic system).

POWER FACTOR. Ratio of true power to apparent power in an alternating-current circuit. (In single-phase circuits a wattmeter indicates the true power and the product of the voltmeter and ammeter readings gives the apparent power. The true power divided by the apparent power gives the power factor. In 3-phase circuits the volt-ampere reading must be multiplied by 1.732 to obtain correct values for the power factor.)

PROTECTED. Provided with one or more fuses or current-interrupting devices.

RESISTOR. An aggregation of one or more units possessing the property of resistance and used in an electric circuit for the purpose of operation, protection, or control of that circuit.

RHEOSTAT. A resistor provided with means for varying its resistance.

SEMIPORTABLE ELECTRIC LAMPS. Lamps provided with extension cords having a limited range over which they may be used.

SHEATH. A lead or other metallic covering for one or more electric conductors.

SINGLE-PHASE CIRCUIT. An alternating-current circuit usually consisting of two wires whose currents have an electrical phase difference of 180°.

STAR OR Y-CONNECTION. Applicable to windings in a 3-phase system - diagrammatically shown as a 3-pointed star or Y; one end of each winding being connected at the center.

STATIONARY ELECTRIC LAMPS. Lamps in a fixed position operated from either a power circuit or battery.

STATIONARY MOTORS. Motors not included under portable motors.

SUBSTANDARD EQUIPMENT. Electrical apparatus of the explosive-proof type lacking the full requirements of the United States Bureau of Mines.

SUBSTATION. A station in which electric current is changed in character or voltage.

SURFACE INSTALLATIONS. All electrical apparatus and circuits on the surface under the control of the mine.

SWITCH. A device for making, breaking, or changing connections in an electric circuit.

SWITCHBOARD. The essential mounting common to one or more pieces of switchgear or measuring instruments, or both.

SWITCHGEAR. Switches, relays, contactors, circuit breakers, and other devices used for the protection or control of electrical apparatus and circuits.

THREE-PHASE CIRCUIT. A combination of three alternating-current circuits (usually 3 wires) whose currents have an electrical phase difference of 120°.

TRANSFORMER. A transformer is a form of stationary induction apparatus used in alternating-current systems to transform the electric voltage or current applied to one winding commonly called the primary to a higher or lower value in another winding known as the secondary.

TWO-PHASE CIRCUIT. A combination of two alternating-current circuits (usually 4 wires) whose currents have an electrical phase difference of 90°.

UNDERGROUND INSTALLATIONS. All electrical installations below the surface.

UNDERGROUND STATION A place in which there are permanently installed one or more transformers, switchboards, or electrical machines.

VOLT. The practical unit of electrical pressure. (Analogous to head in a hydraulic system).

VOLTAGE. The difference in potential or pressure between two points in an electrical system. (Analogous to difference in head in a hydraulic system.)

VOLTMETER. An instrument for measuring difference of potential, indicating in volts.

WATT. A unit of electrical power.

WIRE GAGE. In the electrical safety code all reference to wire sizes shall mean American wire gage (A.W.G.).

GENERAL RULES

Experienced man in charge

1. At each mine where electricity is used underground there should be in charge of the electrical equipment a man fitted for his position by ability, training, and experience. The character of the equipment will determine the qualifications of the mine electrician, and he should be thoroughly familiar with the operation and maintenance of the equipment under his charge.

Plan of electrical installation should be kept

2. A plan should be kept at the mine showing the location of all permanently installed electrical machinery and apparatus in connection with the mine electrical system, including cables, conductors, lights, motors, switches, trolley lines, and transformers. This plan should be of sufficient size to show clearly the location of such apparatus and should state the capacity in horsepower, kilowatts, or kilovolt-amperes as appropriate for each motor, transformer, etc., and should give the nature of its duty. Such plan should be corrected as often as may be necessary to keep it up to date, at intervals not exceeding six months.

Periodic inspection and written report should be made

3. At each mine where electricity is used underground a systematic inspection of all wiring and equipment should be made at regular intervals, at least once every month. A report of each inspection should be made by the mine electrician or inspector, and a copy of this report should be furnished to the mine foreman and kept on file at the mine. The report should definitely state the condition of each underground station, of the conductors and controlling appliances of each main and branch power and lighting circuit, and of the motors and controlling appliances of each locomotive, mining machine, pump, hoist, or other piece of electrical apparatus connected to the electrical system of the mine.

Defective equipment should be reported and removed from service

4. A report should be promptly made to the mine official in charge or to a person designated by him to receive such reports, of every breakdown of any part of the electrical equipment in or about the mine, or of damage or injury thereto, or of any overheating, or of the appearance of sparks or arcs outside of the inclosing casings, or when any part of the equipment, not a part of the electric circuit, becomes alive. It should be the duty of the person first observing such breakdown, injury, damage, sparking, arcing, or the fact that some part of the equipment, not so supposed to be, is alive, to make such report or to communicate such fact to the person in charge of the equipment, who should in turn make a report to the proper mine official.

Instruction of workers

5. No person should be allowed to work on or with electrical equipment of any kind unless he has been previously instructed by an authorized person in the performance of his duties.

Workmanship

6. Care should be taken to insure good mechanical construction and neat workmanship in connection with all wiring and installation of equipment.

7. No person working in or about a mine should wilfully cause another person to receive an electric shock. No person should, without authority, handle or tamper in any way with electric wires or conductors, or electrical apparatus of any kind, or enter an electrical machine room or underground station.

Tampering with electrical circuits forbidden

8. Repairs, renewals, or extensions of electrical apparatus and circuits should be made while such apparatus or circuits are not alive. If conditions are such that repairs need be made on live apparatus or circuits the utmost precaution should be taken when working on them. Gloves or mats of rubber or other suitable insulating material should be provided and be used by persons making repairs to live apparatus or circuits, or when live parts of electrical apparatus need be handled for the purpose of adjustment. When working on apparatus or circuits that have been disconnected from the power supply precaution should be taken to prevent unauthorized persons from closing switches that will cause such apparatus or circuits to become alive.

Electrical workers should observe precautions

9. Caution notices should be posted at points where such warnings will be most effective in reducing the likelihood of contact with live or moving parts, and prohibitory notices should be posted wherever electrical apparatus that should not be manipulated by unauthorized persons is installed.

Posting of caution notices

10. There should be posted prominently in every surface and underground station and at the entrance to the mine instructions for the restoration of persons suffering from electric shock. All employees who work with or on electrical apparatus should know how to carry out these instructions without delay.

Resuscitation notices should be posted

11. Space should be provided for free movement where regular passing is required or permitted around all unguarded parts of the electric system, and places where persons must pass close to or adjust permanently installed electrical machinery should be sufficiently lighted.

Ample space around equipment

12. The unoccupied space around all electrical equipment should be kept as dry as practicable. At any place where it is necessary to manipulate or adjust live equipment operating at more than 300 volts (including switches, motor starters, and other controlling appliances) there should be provided and available an insulated platform or mat which may be of a form and character most in keeping with the circumstances of its use, and which should be not less effective than a dry board 3 feet by 15 inches by 7/8 inch. Locomotives and machines that are moved so frequently that they are provided with trailing cables are excepted.

Insulated platforms or mats should be provided

Grounding machine frames

13. All metallic frames, casings, and coverings of stationary equipment that may become alive should be permanently grounded. Portable machines other than locomotives, whose frames are not in intimate contact with the earth, should have their frames grounded.

Metallic sheaths should be grounded

14. All metallic sheaths or armors of cables should be electrically continuous throughout and should be effectively grounded. Weatherproof varnished cloth, rubber, or similar insulation, unless inclosed in a metallic sheath or armor, or both, when used underground would not be considered as a protection against shock.

Pipe lines should be grounded

15. In mines where a grounded return system is used all underground metallic pipe lines 1000 feet in length or over, and all metallic pipe lines leading outside the mine should be bonded to the return at the ends and at intervals not exceeding 500 feet. All metallic pipes in shafts and boreholes should be bonded to the return at top and bottom.

Motor connections should be insulated or guarded

16. The connections of all motors should be guarded from accidental contact by insulation or grounded coverings. Motors that operate at voltages exceeding 300 should have their outgoing connections entirely within the motor frame or bedplates, or such connections guarded against accidental contact.

Wires should be guarded

17. Where danger exists of accidental contact with wires carrying electric current the wiring should be guarded. In haulage roads used as traveling ways the wires need not be guarded if a traveling way of approved dimensions is provided on the side of the entry opposite the wires. Where wires are run in an entry in which no one but authorized persons is allowed to travel, or where no hazard from contact exists the wires need not be guarded.

Voltage for underground circuits

18. Voltages exceeding 600 should not be used underground, except under the following conditions: (1) Such circuits should be carried inside metallic sheaths or coverings; (2) the sheath or covering should be permanently grounded; and (3) these voltages should be applied only to transformers or to motors in which the high-voltage windings are a part of the stationary element.

Rating of equipment

19. All electrical equipment should be rated in accordance with the current standards of the American Institute of Electrical Engineers.

Operated at rated capacity

20. All equipment should be operated within its rated capacity as defined by the current standard of the American Institute of Electrical Engineers.

Name plates should be provided

21. The rating of each piece of electrical equipment should be stamped on it or inscribed on a metal plate suitably mounted and maintained upon the equipment. The inscription on the plate should indicate whether the rating is for continuous or intermittent service and should be in accordance with the name-plate requirements of the American Institute of Electrical Engineers.

Fire protection should be provided

22. Buckets filled with clean, dry sand or rock dust should be kept in all underground stations for immediate use in extinguishing fires. The minimum amount of sand thus stored in any one station should not be less than 2 cubic feet. No sand should be required if two or more fire extinguishers approved for use on electrical equipment are kept in each station.

Rules Pertaining to Machines and Apparatus

General suggestions for machines and apparatus

23. Electrical machines or apparatus should be rugged in design and ample in capacity, with current carrying parts effectively insulated. Stationary machines or apparatus should be installed in a permanent and workmanlike manner on substantial fireproof foundations or supports and, insofar as practicable, should be housed in fireproof rooms and so guarded that they do not offer an apparent hazard to either life or property. The etallic frames of all stationary equipment should be permanently grounded.

Motor generators and rotary converters

24. Stationary motor generators and rotary converters should be installed in an adequately ventilated room so selected as to avoid excessive moisture or dust accumulation.

Stationary motors

25. Stationary motors for general application should be installed in a well ventilated space so selected as to avoid excessive moisture or dust accumulation.

Switchboard, construction details

26. Switchboards should consist of substantial frame work of iron pipe or structural steel on which each piece of control equipment is mounted. Equipment should be mounted on the steel work or on insulating panels supported by the steel work.

Switchboards, installation requirements

27. Switchboards should be so located that there will be a clear space of at least 3 feet in front and back of them. Additional space should be provided if it is necessary for the safe adjustment and manipulation of the equipment. This space should be kept clear of inflammable or obstructive material. Where the voltage exceeds 300 volts the switchboard should be entirely surrounded with walls or gratings and should be kept closed by locked doors that can be opened from within without the use of a key but from without with a key only. The last requirement applies only in case there are live conductors on the front of the switchboard. Where no live conductors exist in front of switchboards, space back of the boards should be fenced.

Switch gear, special suggestions

28. Switch gear should be mounted on switchboards or metallic supports. The wiring between equipment and switch gear should be done in a workmanlike manner and in so far as practicable placed in iron conduit unless armored cable is used. Control of the switch gear should be near the equipment and in sight thereof. Switches should be provided for all apparatus and so arranged as to permit complete disconnection of the power circuit.

Instruments provided for generators

29. There should be provided for each generator an indicating ammeter or wattmeter of suitable capacity, and for all generators a voltmeter that by closing a switch or manipulating a plug connection can be connected to any generator.

Rheostats and resistors - special rules

30. Rheostats and resistors, including any insulation of the wires used in the internal wiring should be constructed of incombustible material and should be mounted upon fireproof bases or framework. All rheostats should be so constructed as to have no exposed live contact points.

Shaft hoist - overwinding

31. All electrically operated shaft hoists should be provided with a device approved for the prevention of overwinding. Where the hoist is used for handling men additional provision should be made to prevent overwinding at the man landing. When a separate overwind protection for men is used, a visual signal should be provided to indicate at all man landings and at the hoist house that the overwind device is set for hoisting men. It should not be possible to operate the signal lights without setting the man-landing overwind.

Shaft hoist - brake

32. Shaft hoists should have a brake that will keep the hoisting drum under the control of the operator. This brake should be provided with an automatic trip or release that will properly apply the brake in case the power supply fails, in case of overwinding or overspeeding, and this brake should have sufficient capacity to hold the maximum unbalanced load. Any contingency which will cause an emergency application of the brake should remove power from the motor.

Man hoist - speed

33: Hoists for handling men should be so arranged that when hoisting or lowering men the legal rate of speed can not be exceeded. If hoists are designed to operate in balance, the driving motor should be of sufficient size to hoist full loads of men in maximum unbalanced condition in case of emergency.

Man hoist - operation

34. Hoists used for handling men should not be so operated unless all equipment, including protective devices, are in normal operating condition. All safety devices should be inspected daily and tests as frequently as necessary to prove their reliability. A record of such tests should be made and signed by an authorized person and kept on file at the mine.

35. All electrically operated gravity, tail-rope, or endless-rope hoists used in connection with main-rope haulage should be fitted with adequate controlling devices of approved design. Main-rope haulage

36. All electrical equipment on tipples and other surface structures should be installed in accordance with the rules of the National Electrical Code and the National Electrical Safety Code and with any existing State or municipal regulations. Tipple equipment installation

37. Motors on tipples should be equipped with control that will automatically disconnect the power from line in case of power failure, and if practicable such control apparatus should be located within sight of the motors that they control and the machines that they operate. A switch or other means for disconnecting the motor from the power supply should be installed near the machinery. Tipple motors, control

38. All electrically driven main mine-ventilating fans should be constructed of fireproof material and installed in fireproof buildings and inclosures. Fan building and inclosures

39. Motors that operate ventilating fans should be of sufficient capacity to drive the fan without overloading. Fan motors - capacity

40. Where stopping the fan would place in jeopardy the lives of men underground, a duplicate connection from the fan to the power supply should be provided on a separate line of poles if the regular line is so exposed as to be liable to failure, except at mines where reserve equipment is maintained for emergency operation of the fan. Motor-controlling appliances used with motors that are not arranged for automatic starting should be so installed that the motor will be disconnected automatically from the supply circuit in case the power supply fails. Power failure protection

41. Any stoppage of the fan should be reported at once to the man directly in charge of the operation of the mine and, where feasible, means for direct communication between the fan house and the generating station or substation supplying the power should be provided. In cases where the fans are equipped with automatically controlled equipment, an approved warning device should be provided to indicate abnormal conditions of the mine ventilating system. A person receiving such signal should report the fact immediately to the man directly in charge of the operation of the mine. Fan stoppage, report

42. The responsibility for the operation of electrically driven mine-ventilating fans should devolve upon an authorized person. Fan operator

Locomotives - special provisions

43. Locomotives should be provided with current interrupting devices in the main and headlight circuit and should be equipped with a headlight at each end of the locomotive. Locomotive headlights should be so located as to be adequately guarded from danger by mine cars or from material falling or projecting from the cars. Locomotive wiring should be heavily insulated with a good grade of rubber, and wherever practicable the wiring between compartments should be installed in rigid metallic conduit or flexible hose conduit. If the insulation or other protective features of the locomotive wiring is in any way disturbed in making repairs great care should be used in replacing such insulation and protective features before the locomotive is again put in service. Locomotives used in or near the face workings should receive special attention with respect to the safety of the individual accessories and wiring between them.

Permissible locomotives - inspection and maintenance

44. In places where there is likelihood of methane or coal dust accumulating in dangerous proportions only permissible electric locomotives should be used. In inspecting or repairing permissible locomotives careful attention should be given to the precautionary statements included on the approval plate. These statements are intended for guidance in maintaining the locomotive in a permissible condition.

Coal-cutting outfits - general provisions

45. Electrically operated coal-cutting outfits should be rugged in construction. The motor or motors, together with the wiring from the motors to their control, should be protected by automatic circuit-interrupting devices. Each ungrounded conductor in a machine connected to a grounded circuit should be protected, and all conductors should be protected in machines connected to ungrounded circuits. Frames of motors and their control should be connected to a common ground, preferably to the base of the machine which they operate. All wiring between electrical accessories should be heavily insulated and installed in rigid conduit, flexible hose conduit, or other adequate means used to guard it from mechanical injury. See rules for circuits for suggestions covering the use, inspection and maintenance of trailing cables used with coal cutting outfits.

Permissible coal-cutting outfits - inspection and maintenance

46. In places where there is a likelihood of methane or coal dust accumulating in dangerous proportions only permissible coal cutting outfits should be used. In inspecting or repairing permissible coal-cutting outfits careful attention should be given to the precautionary statements included on the approval plate. These statements are intended for guidance in maintaining the outfits in a permissible condition.

Nonpermissible coal-cutting outfits

47. Where nonpermissible coal-cutting outfits having substandard electrical accessories are used in gassy or dusty mines very special attention should be given to their operation, inspection, and maintenance, so that the outfits shall be as safe as their construction will permit.

48. Electrically operated coal-handling outfits for underground

Coal-handling outfits, general provisions

service, including loading and shoveling outfits and conveyors, should be rugged in construction. The motor or motors, together with the wiring from the motors to their control, should be protected by automatic circuit-interrupting devices. Each ungrounded conductor in a machine connected to a grounded circuit should be protected, and all conductors should be protected in machines connected to ungrounded circuits. Frames of motors and their control should be connected to a common ground, preferably to the base of the machine which they operate. All wiring between electrical accessories should be heavily insulated and installed in rigid conduit, flexible hose conduit, or other adequate means used to guard it from mechanical injury. See rules for circuits for suggestions covering the use, inspection, and maintenance of trailing cables used with coal-handling equipment.

Permissible coal-handling outfits - inspection and maintenance

49. In places where there is a likelihood of methane or coal dust accumulating in dangerous proportions only permissible coal-handling ould be used. In inspecting or repairing permissible coal-handling outfits careful attention should be given to the precautionary statements included on the approval plate. These statements are intended for guidance in maintaining the outfits in a permissible condition.

Nonpermissible coal-handling outfits

50. Where nonpermissible coal-handling outfits having substandard electrical accessories are used in gassy or dusty mines very special attention should be given to their operation, inspection, and maintenance, so that the outfits shall be as safe as their construction will permit.

Electrically operated room hoists - general provisions

51. Electrically operated room hoists should be rugged in construction. The rooms in which they are installed should be well-timbered to prevent damage of the equipment from falls of rock or coal. Stationary wiring used in furnishing power to the hoist should be protected by a circuit-interrupting device and mechanically guarded from falls of rock or coal. The same rules hold for portable hoists with respect to protection, and grounding of accessories, wiring, and care of trailing cables as given for coal-cutting outfits.

Permissible room hoists - inspecion and matintenance

52. In places where there is a likelihood of methane or coal dust accumulating in dangerous proportions only permissible room hoists should be used. In inspecting or repairing permissible room hoists careful attention should be given to the precautionary statements included on the approval plate. These statements are intended for guidance for maintaining the outfits in a permissible condition.

Nonpermissible room hoists - special precautions

53. Where nonpermissible room hoists having substandard electrical accessories are used in gassy or dusty mines very special attention should be given to their operation, inspection and maintenance that the outfits shall be as safe as their construction will permit.

Electrically operated pumps

54. Electrically operated pumps should be rugged in construction. The rooms in which they are installed should be timbered well to

prevent damage of the equipment from falls of rock or coal. Stationary wiring used in furnishing power to the pump should be protected by a circuit-interrupting device and mechanically guarded from falls of rock or coal. In general the same rules hold for portable pumps with respect to protection, grounding, or accessories, wiring and care for the trailing cable as given for coalcutting outfits.

Permissible

Permissible pumps-inspection and maintenance

55. In places where there is a likelihood of methane or coal dust accumulating in dangerous proportions only permissible pumps should be used. In inspecting or repairing permissible pumps careful attention should be given to the precautionary statements included on the approval plate. These statements are intended for guidance in maintaining the outfits in a permissible condition.

Nonpermissible pump - special precautions

56. Where nonpermissible pumps having substandard electrical accessories are used in gassy or dusty mines very special attention should be given to their operation, inspection and maintenance that the outfits shall be as safe as their construction will permit.

Electrically operated drills and drilling machines - general provisions

57. Portable electric drills and drilling machines should be rugged in construction. Drills held in the hands during operation should have a separate ground wire attached to the drill frame. This ground wire should be connected to an adequate ground return and kept in good condition. In general, the same rules hold for drilling machines with respect to protection, grounding of accessories, wiring, and care of the trailing cable as given for coal-cutting outfits.

Permissible drills and drilling machines - inspection and maintenance

58. In places where there is a likelihood of methane or coal dust accumulating in dangerous proportions only permissible drills and drilling machines should be used. In inspecting or repairing permissible drills and drilling machines, careful attention should be given to the precautionary statements included on the approval plate. These statements are intended for guidance in maintaining the outfits in a permissible condition.

Nonpermissible drills and drilling machines

59. Where nonpermissible drills and drilling machines having substandard electrical accessories are used in gassy or dusty mines very special attention should be given to their operation, inspection and maintenance that the outfits shall be as safe as their construction will permit.

Miscellaneous equipment - general provisions

60. Miscellaneous electrically operated portable equipment such as air compressors, rock dusting machines, etc., should be rugged in construction. In general the same rules hold for miscellaneous equipment with respect to protection, grounding of accessories, wiring and care of the trailing cable as given for coal cutting outfits.

61. In places where there is a likelihood of methane or coal dust

accumulating in dangerous proportions only permissible air compressors, rock-dusting machines, etc., should be used. In inspecting or repairing permissible air compressors, rock-dusting machines, etc., careful attention should be given to the precautionary statements included on the approval plate. These statements are intended for guidance in maintaining the outfits in a permissible condition.

Permissible miscellaneous equipment - inspection and maintenance

62. Where nonpermissible air compressors, rock-dusting machines, etc., having substandard electrical accessories are used in gassy or dusty mines very special attention should be given to their operation, inspection, and maintenance, so that the outfits shall be as safe as their construction will permit.

Nonpermissible miscellaneous equipment - special precaution

63. Stationary lamps in workshops, motor pits, barns, and other underground rooms as well as lights at landings and around the foot of shafts or slopes should be installed with fixtures that are a part of the rigid conduit system. Drop cords should not be used. Not more than 24 lamps should be in a single circuit, and power consumed in such a circuit should not exceed 1,300 watts. Lamps installed along roadways where no gas or dust hazard is involved need not be mounted on conduit fixtures but may be attached to weatherproof sockets having lead wires supported on insulators.

Stationary lamps - general suggestions

64. In places where there is a likelihood of methane or coal dust accumulating in dangerous proportions, portable electric lamps of the permissible type should be used for illumination.

Permissible portable electric lamps

65. In places where there is a likelihood of methane or coal dust accumulating in dangerous proportions, only approved stationary electric lamps and sockets should be installed. If permissible lamps and sockets are available they should be used.

Stationary lamps - in hazardous atmospheres

66. Portable shot-firing machines of the magneto type should be substantially constructed, having the working parts inclosed in a strong, tight casing. Each machine should be equipped with a detachable handle, connecting plug, key, or similar approved device without which the shot-firing circuit can not be closed, and which should under no circumstances pass from the custody of the person authorized to fire shots.

Single-shot blasting outfits, magneto type - special rules

67. Primary or secondary batteries used for shot firing should be inclosed in a well-constructed casing provided with a special form of contact plug for making the connection between the batteries and the shot-firing leads. The design of the plug should be such that considerable pressure will be required to make the contact, which will be broken immediately unless the plug is forcibly held in position. There should be no exposed contacts on the outside of the battery casings.

Single shot blasting outfits, battery type-rules

Shot firing electrically - safeguards

68. Only authorized persons should be allowed to fire shots electrically in a mine. No shot-firing device should be connected to the shot-firing leads until all other steps preparatory to the firing of the shot have been completed and all persons have moved to a position of safety. Immediately after the firing of a shot the firing leads should be disconnected from the source of electricity, and no person should approach a shot which electricity has failed to explode until the firing leads have been disconnected and until an interval of 10 minutes has elapsed since the last attempt to fire the shot.

Telephones - general suggestions

69. Telephones should be designed for underground service and constructed so as to guard the essential parts of the telephone from dust and moisture. Every mine employing more than 10 men underground should be equipped with a telephone system that should afford communication from the surface to the bottom of each of the underground levels or landings, and from the surface to each parting or siding in the working sections of the mine. In complying with this rule the telephone may be located at the most advantageous points underground, but in no case should any part of the working section be more than 1,500 feet from the nearest telephone.

Permissible telephones - maintenance and inspection

70. In places where there is a likelihood of methane or coal dust accumulating in dangerous proportions only permissible telephones should be used. In inspecting or repairing permissible telephones careful attention should be given to the precautionary statements included on the approval plate. These statements are intended for guidance in maintaining the outfits in a permissible condition.

Circuit-interrupting devices - general suggestions

71. Contactors, circuit breakers, and other current-interrupting devices should be mounted on incombustible supports and guarded as far as feasible from mechanical injury, dampness, and dust. Circuit breakers should have visible means of determining their current setting. All current-interrupting devices should be so located and guarded that persons will not be injured by their operation.

Switches - general suggestions

72. All switches intended for underground use should be rugged in construction and adequately proportioned and where practicable of the safety inclosed type. Knife switches operating on circuits having potentials exceeding 125 volts should be designed so as to prevent excessive arcings. In so far as possible, switches should be located in a relatively dry place. If switches can not be so located an insulated platform should be provided for the man to stand on when operating the switch. Where practicable, switches should be so designed or wired that they will not close by gravity. Switches should be conveniently located and accessible, yet so safeguarded that the liability of accidental contact with the live parts will be reduced to a minimum. Air-break switches used as disconnecting switches should not under any circumstances be used to open circuits under load. Where there is danger of accident due to the inadvertent closing of an open switch means should be provided for locking the switch in the open position.

Permissible switches or junction boxes - inspection and maintenance

73. In places where there is a likelihood of methane or coal dust accumulating in dangerous proportions only permissible switches or junction boxes should be used. In inspecting or repairing permissible switches or junction boxes careful attention should be given to the precautionary statements included on the approval plate. These statements are intended for guidance in maintaining the outfits in a permissible condition.

Nonpermissible switches or junction boxes - special precautions

74. Where nonpermissible switches or junction boxes having substandard electrical accessories are used in gassy or dusty mines, very special attention should be given to their operation, inspection, and maintenance, so that the outfits shall present as little hazard as their construction will permit.

Insulated conductors - capacity

75. The size of insulated conductors and cables used in underground installations should be determined by reference to table of current carrying capacity set forth in National Electrical Code.

Bare conductors - maximum carrying capacity

76. The size of bare conductor used in underground installations should be determined by reference to the following table:

Size of conductor, A.W.G.	Current capacity, amperes	Size of conductor, circular mils	Current capacity, amperes	Size of conductor, circular mils	Current capacity, amperes
10	80	250,000	690	750,000	1,520
8	105	300,000	790	800,000	1,590
6	145	350,000	880	850,000	1,660
4	210	400,000	965	900,000	1,730
2	280	450,000	1,050	950,000	1,800
1	320	500,000	1,140	1,000,000	1,870
0	375	550,000	1,215		
00	435	600,000	1,285		
000	525	650,000	1,370		
0000	615	700,000	1,450		

Note: These values give the maximum carrying capacity of bare conductors and are based on heating effect.

Installation of circuits - general provisions

77. All underground circuits should be properly installed in a permanent manner. Proper installation should mean support on insulation adequate both mechanically and electrically, taking into consideration weights to be supported, the voltage to the circuit, clearance from grounds interference with other circuits, and liability to damage from the usual mining hazards. Lighting circuits and branch power circuits should be given the same degree of care in installation as power circuits of the same

nominal voltage. All wiring between motors and their controlling appliances should be insulated or guarded.

Circuits - general provisions for protection

78. All circuits leading from generating stations and substations should be provided at their source with current-interrupting devices of such capacities and so installed and adjusted that the circuit will be opened if the current in the circuit exceeds the carrying capacity of the conductors leaving the stations. All circuits leading underground exceeding 50-kw. capacity should be provided with a suitable ammeter or means for inserting a portable ammeter.

Two-wire circuits-protection

79. Two-wire ungrounded direct-current circuits should be protected by an automatic circuit breaker or by a fuse and switch in each wire. Two-wire grounded direct-current circuits should be protected by a switch and with an automatic circuit breaker or a fuse in the ungrounded wire. When the circuit breaker trips free from the closing handle, the switch may be omitted.

Three-wire circuits - protection

80. Three-wire direct-current circuits should be protected by a fuse or automatic circuit breaker in each outside conductor but no fuse or circuit breaker in the neutral conductor, and in addition by a triple-pole switch to isolate the fuse or circuit breaker from live sources. Where one of the outside wires is grounded this should be treated as neutral and protection provided only in the other two wires.

Three-phase circuits - protection

81. Three-phase delta or Y (star) connected alternating-current circuits should be protected by a fuse or an automatic circuit breaker in each ungrounded wire. When automatic circuit breakers are used two overload trip coils should be provided for ungrounded neutral systems. In any case the automatic circuit breaker should be so arranged that the opening of one phase will open the other phases. Switches should be provided to isolate the fuses or circuit breakers from live sources.

Circuits leading underground - protection

82. Each circuit that leads underground and extends over the surface of the ground 500 feet or more from the generating station or substation should be equipped with lightning arresters of approved type with proper ground connection at the generating station or substation and also at the point where the circuit enters the mine.

Circuits leading underground, lightning protection

83. Lightning arresters should be connected on the secondary side of all transformers that feed underground circuits, unless there is provided other suitable means for discharging abnormal voltages. Lightning arresters on the primary side will be considered suitable if the secondary circuit above ground is less than 50 feet long.

84. Each power conductor leading underground should be provided

with a switch capable of opening the circuit under full load. This switch should be placed where the circuit enters the mine or within 100 feet of the point, unless the circuit is controlled by a separate switch or circuit breaker at the substation. The design of the circuit breaker should be such that all ungrounded conductors of the circuit shall be opened at the same time in case of an overload on one or more conductors.

Circuits leading underground - switch requirements

85. All underground transformers should be equipped with automatic current-interrupting devices in the primary and secondary side. When the voltage of circuits entering or leaving underground transformers exceeds 600 volts current-interrupting devices should consist of an oil-break switch in each conductor, and each switch should be provided with an overload trip. Circuits not exceeding 600 volts should have one of the following in each conductor where entering or leaving the transformer, except that no fuse or automatic circuit breaker should be placed in a grounded conductor: (1) An oil-break automatic circuit breaker; (2) an inclosed switch and fuse; and (3) an inclosed switch and automatic air-break circuit breaker.

Underground transformer circuits protection

86. The resistance of any circuit should not be so great that a complete short circuit at any point will fail to operate the current-interrupting device that protects the circuit.

Circuit - allowable resistance

87. The tracks of all main systems that use a rail return should be bonded at every rail joint, and cross bonding should be placed at intervals not exceeding 200 feet. Special provision should be made for bonding around all switches and frogs to insure a continuous return.

Rail return - bonding

88. All joints in conductors or cables should be made electrically and mechanically efficient either by the use of an approved mechanical connection or by soldering. Splices should be such that the conductivity at the joint is not less effective than at any other point in the conductor or cable.

Joints and splices

89. If the line supplying power to a fan motor is exposed to the influence of lightning, lightning arresters with an efficient ground should be placed near the point where the wires enter the fan house.

Fan circuits, lightning protection

90. All power conductors installed in shafts should be covered with approved insulating material throughout or guarded in an approved manner. They should be securely fastened in such a way as to support the conductor properly. Conductors used as returns in shafts for ground-return systems should be supported on insulators but need not be covered with insulation. Shaft cables that are so constructed that the whole or any part of the cable is not self-sustaining should be supported in an approved manner at such intervals as may be necessary to prevent the occurrence of un-

Shafts - installation of circuits

due strains in sheath, insulation. or conductors. Shaft cables should be so placed or protected that they are not liable to injury from falling material.

Boreholes - installation of circuits

91. All conductors leading underground through boreholes should be installed in an approved manner that should prevent the occurrence of undue strains in sheath, insulation, or conductors. Telephone or signal wires should not be installed in the same borehole with power wires unless either the signal or the power conductors in the borehole are incased in metallic coverings that are effectively grounded.

Drifts or slopes - installation of circuits

92. Conductors of power circuits in drifts or slopes not exceeding 600 volts may be installed bare but should be carried on suitable insulators securely fastened to the sides or roof of the entry. If the drift or slope is used for traveling, the conductors should be guarded.

Power and lighting circuits in traveling ways - guarding

93. All conductors in traveling ways except haulage roads used for traveling and medium voltage conductors in room entries should be guarded throughout that part of the entry that is used for traveling, unless the conductors are at least 7 feet above the rail, in which case guarding will be necessary only at those points where men are required to work beneath the conductors or pass under them.

Trolley wires - general provisions

94. Trolley wires should be of hard-drawn copper not smaller in size than No. 0 and should be securely supported on approved hangers. Trolley wires should be placed 6 inches outside of the rail, kept in as straight a line as practicable, and installed on the side of the entry opposite from shelter holes or traveling way or space. The height of trolley wires above the top of the rail should be made as uniform as possible. On straight runs the hangers should be placed not more than 20 feet apart where the height of the roof above the track is 5 feet or less and not more than 30 feet when the height above the track is more than 5 feet. In any event, the sag of wire between any two adjacent hangers shall not exceed 3 inches. On curves the hangers should be placed so close together that the trolley wire at any one hanger may be entirely disconnected without exposing the locomotive runner to danger of contact. Sectionalizing switches should be placed in the underground trolley and feeder circuits at intervals not exceeding 2,500 feet. These switches should be arranged so they can be locked in the open position. All branch trolley circuits should be provided with a frog at the point where they leave the main circuit and also with a switch installed at or near the frog, by which the branch can be disconnected from the main circuit. Trolley circuits that are less than 7 feet above the top of the rail should be guarded at the points where men are required to work or pass under them.

95. All power conductors transmitting current not exceeding 600

volts and paralleling a trolley wire should be installed at least 6 inches from the trolley wire and on the nearest rib side of it, and should be supported on insulators of an approved type. Exception can be made where the hanger is designed to support the feed wire. When the height of the wire does not exceed 5 feet the insulators should be placed not more than 20 feet apart and as much closer as may be necessary to support the wires properly. If the height of the wire is more than 5 feet the insulators should be placed not more than 30 feet apart and as much closer as may be necessary to support the line properly. Sectionalizing switches should be placed at intervals not exceeding 2,500 feet in all underground feeder circuits operating at not more than 600 volts. When two or more sectionalizing switches are used for the same section of a mine they shall be installed as close together as is feasible. All sectionalizing switches should be arranged so that they can be locked in open position. The negative or return wire of grounded machine circuits should be afforded the same support and insulation as the positive or live wire. Electric circuits should not be installed along return airways or in other sections of the mine not regularly inspected. Conductors may be permitted to cross such an air course if they are so installed and guarded that they can not be damaged by falls of rock, coal, or other disturbances that might occur in places not regularly inspected.

Power conductors - general provisions

96. Branch circuits should be installed and maintained in the same manner as main conductors. At a point where a branch circuit leaves the main circuit there should be placed a switch that will cut off all current from the branch circuit. The conductors of branch circuits for operating mining machines should be not smaller than No. 4 A.W.G. copper wire. The conductors of pump circuits should be not smaller than No. 8 A.W.G. Entries or passageways in which wires are installed must be kept sufficiently free from rock, slate, or other material to permit ready access to the wires at all times.

Branch circuits - general provisions

97. Rooms where permissible equipment is required should not be wired. This should not prevent running approved trailing cable into the rooms for the purpose of operating permissible equipment.

Rooms should not be wired

98. Lighting wires along haulage roads may be attached to power wires by soldering or by fastening under a set screw in a lug attached to the trolley hanger, or by such other devices as will prevent the wires from becoming loose. No wires smaller than No. 14 A.W.G. should be used for lighting circuits. When the rail is used as a return for lighting circuits the return wire should be attached to the rail in an approved manner. This ground connection should be made of not less than No. 8 A.W.G. copper wire which should be buried below the surface and carried to the side of the entry and thence on approved insulators to the roof or to a point at least 7 feet above the track. All sockets should be of the weatherproof type and supported on porcelain insulators.

Lighting circuits on haulage roads

Signal and telephone circuits general provisions

99. Underground battery signal circuits and telephone wires should not be installed on the same side of any entry as trolley wires or other power conductors. Where signal or telephone wires cross trolley or power wires they should be insulated and boxed in or incased in conduit. Suitable precautions should be taken to prevent electrical signal or telephone wires from becoming grounded or from coming in contact with other underground electric conductors.

Shot-firing circuits (inside firing) general provisions

100. Special precautions should be taken to prevent shot-firing conductors from becoming grounded or from getting in contact with other electric circuits. Wires used in firing single shots within the mine should be rubber covered and not exceed the following lengths: 600 feet for No. 14, 350 feet for No. 16, or 200 feet for No. 18.

Shot-firing circuits (outside firing) - general provisions

101. In coal mines employing the system of firing shots electrically from above ground an ungrounded metallic circuit should be employed. All shot-firing lines should be adequately insulated. The two wires that form the circuit should be placed on the side of the entry or passageway opposite that on which the trolley wire or other power wires are placed. The following switches should be installed in the shot-firing circuit; No. 1, a locked firing switch in the shot-firer's cabin; No. 2, a locked switch in the power house; No. 3, a 5-foot lightning gap (disconnecting switch) at the foot of the shaft or slope or at the drift entrance, which switch should be arranged for grounding the incoming circuit when not in service; No. 4, a locked switch at the entrance to each heading or side entry; No. 5, a switch at the mouth of each working place. The following special precautions should be used in operating outside shot-firing system:- Detonators shall not be connected in straight parallel; that is, no single detonator should be connected across the firing circuit. No. 5 switch should be closed first, then No. 4, etc., No. 1, the switch nearest the generator, being closed last. This switch should be closed but once and should not be left closed for more than two-tenths of a second. The timing of the switch should be accomplished mechanically. No switch should be closed until all men have left the part of the mine controlled by the switch.

Trailing cables - general provisions

102. Trailing cables for portable machines should be flexible and adequately insulated. The trailing cable should be divided at the motor, but only for such length as is necessary for making connection to the motor; and the cable, with its outer covering complete, should be clamped securely to the motor frame in such a manner as to guard the cable from injury and to prevent any mechanical strain being borne by the divided ends that make electrical connection to the motor.

Protection

103. Trailing cables on portable equipment should be protected by a fuse or circuit breaker.

Inspection

104. The machine operator should examine each trailing cable daily for abrasion and other defects, and he should also be required to observe carefully the trailing cable while in use. If the trailing cable breaks down in service or causes a person to receive a shock it should be at once put out of service and should not be used until it has been repaired and tested by an authorized person.